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for example, the well-known displacement from strict periodicity of argon, cobalt and tellurium all point to an unequal rate of progression in isolated cases. Thus, this phenomenon seems to be a general one; the various properties of material seem to oscillate with varying rhythms as the atomic weights increase. The variation is so great that one may almost suspect not only varying rhythms but also rhythms represented by different types of mathematical functions.

These facts suggest a possible reason for the great irregularity of the last part of the periodic table. May it not be that the nature of the elements is determined by several fundamental tendencies which may be compared to the Mendelian characters of the modern theory of heredity? If these characters recur at different intervals as the atomic weight increases, a given rhythm occurring at first would necessarily be obliterated toward the end of the system. To change the analogy and borrow a term from the nomenclature of light, we may say that the tendencies which produce the curves in this diagram, might first reinforce and afterwards interfere with one another, because they possess different wave-lengths. At first, overlapping might accentuate one set of properties; later the changing relation might annihilate this set of properties and cause another. Thus, all the varieties of material may be functions of some few fundamental characteristics which progress at different rates as the atomic weights increase.

Any attempt to discover the nature of these fundamental tendencies must be of a highly speculative character. In our ignorance we can not distinguish between cause and effect. The well-known definite relations of the spectrum lines suggest that at least one of the essential requirements for the existence of an atom may be suscep-

tibility to certain definite harmonic vibrations; those compressible atoms capable of vibrating in certain rhythms may be permanent, whilst other aggregations may be unstable. The gap in the periodic system where *ekaiodine ekacæsium* should be, and the amazing instability of the elements immediately following, supports the notion.

But here we have a cosmic puzzle for future solution. To-day we lack adequate data, we are blocked at every turn by our ignorance; therefore, the immediate problem is to discover and test each step as carefully as possible. When the facts have been ascertained, man will have a solid basis upon which to build his future superstructure of theoretical interpretation.

The quest is not dictated by mere curiosity alone. All organic life is actuated by chemical energy, and exists in a mechanism and environment composed of chemical substances; and the effort to understand these essential conditions of human existence constitutes one of the most important objects of human endeavor. Superficial observation of the complex phenomena of life can do but little; as Faraday well knew, patient study of the fundamental laws of the physical universe alone can help to unravel the interwoven threads. Health, well-being and a profound philosophic outlook are alike dependent upon the result. No one can predict how far we shall be enabled by means of our limited intelligence to penetrate into the mysteries of a universe immeasurably vast and wonderful; nevertheless, each step in advance is certain to bring new blessing to humanity and new inspiration to greater endeavor.

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#### SCIENCE AND LITERATURE

SPEECH was given to man to conceal his thoughts, according to some eighteenth-cen-

ture French cynic; and the way in which language is most frequently employed now makes it seem applicable to twentieth-century America. A man is a pessimist who disbelieves in the accuracy of the glowing pictures painted by popular vanity or personal interest, no matter how much faith he may have in more reasonably attested good; and he is an optimist if, either without effort or by the ostrich's expedient of burying its head in the sand, he shows himself absolutely oblivious to the possibility of anything unflattering or uncomfortable ever arising. With equal disregard of their proper application and limitation, the words *science* and *literature* are confused; so that, if anything definite at all is meant by them, it is often something nearer the import of the other, than that of the one employed. It is, of course, not desirable to add to this confusion by attempting to define the words, which are both too extensive in significance for exact definition, but it may not be inappropriate to discuss their meanings to see if any reasons can be discovered to account for their confusion, and for the fact that, mistakenly, they are often used as if they were mutually exclusive, and understanding of or sympathy with the one implied ignorance of or hostility towards the other.

Ultimately, of course, literature and science have the same object—to throw light on the deeper problems of existence; but literature seeks to do this by means of thought, and science by means of knowledge, that is, literature is the product of reflecting on knowledge in its entirety, science devotes itself to systematic observation of its details. The producer of literature, however, must know and observe, just as the scientist must reflect, if he is to be creative; so that each must understand the methods and appreciate the achievements of the other, and inability to do so calls into question a man's right to be considered an author or a scientist, however much pretension he may make to either title. This is the fact of the matter, but contemporary standards are always mediocre, and the popular conceptions of literature and science alike are based on such inferior exhibitions of both that it is

not strange that literature should be associated primarily with subjective conjecture, and science with the perceptions of sense rather than of the intellect, and that literature should be looked on as wholly ephemeral and science as wholly material, as they are.

It is not entirely because of mediocre standards, however, that such notions of the nature of science and literature obtain, but because of the character of modern civilization, and also because of the quality of the ideas that dominate the modern mind. The law of the universe, according to the observation of innumerable philosophers, is flux and flow. The earth moves from perihelion to aphelion, the moon from apogee to perigee, and everything else surveyed by the human mind, as well as the human mind itself, moves with a systole and diastole that, though often obscured by the infinite variety of the movements with which it is complicated, is nevertheless evident to the observant intellect. In the case of the human mind one exhibition of this movement is between an extreme of dependence on the world of sense without it and another of submission to truths disclosed by inward experiences. If a chart or graph of such movements were drawn, provided, of course, that any one dealing in charts and graphs were capable of comprehending the existence of forces as real and extensive as these, it would be shown that, whatever intervening fluctuations there may be, there are periods when the ideas of men rest almost wholly on the principles of their own nature and others in which external forces rule to an equal extent. In the early centuries of the Christian era, when the civilization of to-day was formed, the dominant thought of the world was guided to a remarkable degree by the observation of human nature, and the external world was correspondingly neglected. With an indifference to anything but the necessity of harmonizing all phenomena with preconceived notions equal to that of the German pedant who evolved a description of the elephant solely from his inner consciousness, the entire material world of early Christian times was assumed, in defiance of much obvious evidence to the con-

trary, to be nothing but a vast pantomime illustrating the spiritual world as religious dogma created it. It was not ignorance of the natural world alone that filled the early *bestiaries* with statements that the ass brayed seven times a day to illustrate the seven deadly sins, or did something else three times to illustrate the trinity, and others of a like nature; such statements were disproved by the daily experience of almost everybody, and their wide circulation and general acceptance can only be explained by the fact that the popular intellect was so engrossed with the contemplation of emotional phenomena as to be unconscious of nearly everything else.

To-day the pendulum has swung to the other extreme, and the human mind conceives everything, not in terms of spiritual experience, but according to the analogy of material phenomena; in fact, it is not too much to say that the modern intellect is as devoid of any intelligent insight into human nature as the early Christian mind was of knowledge of natural history. This of course tends to prevent any profound understanding of literature, for literature is concerned primarily with human nature and only secondarily with nature in its ordinary significance. "Mankind," says Goethe, "is ever changing; man remains ever the same"; and it is the business of literature to exhibit this eternal nature of man through the incessant variations of its external environment. In modern times, however, the progress of civilization has vastly increased the physical forces under man's control, and so obscured those fundamental moral powers with the exercise of which literature is concerned, while it has rendered his artificial environment more complex and more varied, so that its reproduction has become a more interesting and a more important task, and has come to be regarded as the chief concern of literature, although in reality it is only one of its less important functions.

The materialistic intellectual preconceptions of modern times and the artificial character of modern civilization have also affected the teaching and interpretation of literature in a way calculated to give an erroneous impres-

sion of its real nature. The pedantry of to-day shows a slavish worship of the literal fact, and, at the same time, an artificiality that is surprising. The human interest is more completely eliminated from literature—whose interest, we have seen, is supremely human—than it ever has been before. A mass of miscellaneous information relating to literary history rather than to literature,<sup>1</sup> mingled with much unsubstantial theorizing and some fragmentary reading is what the colleges present to the student as literary instruction. The classics are no longer taught as the thought of other civilizations; they have become almost exclusively the memorizing of details of accidence and syntax, supplemented at more advanced stages by equally bald and inert information about literary forms or historical relationships. Under these circumstances it is not to be wondered at that the average youth, and every youth who has an acute mind or the courage of his convictions, finds no attraction in the study of the classics. The facts such a study will reveal to him may be complicated and difficult to learn, but so are facts in connection with chemical changes or physical laws; and these latter have, besides their greater direct vocational value, the added advantage of being current and significant to-day and possessed of a greater degree of certitude and demonstrability.

Such is the appeal of literature to the undergraduate, the graduate is no better off. Philology is a significant and interesting study that bears an important relation to the understanding of language, which is the vehicle of literature; but philology is not literature, even though it be a much more secure field for those whose minds are baffled by the illusive nature of that subject. Philology, however, even when it sets itself to tabulating the number of times a certain conjunction or adverb occurs in some author or text, has far more to justify it than the other form of literary scholarship that is most industrious to-day. By this latter the student is encouraged to expend his energies on questions as indeterminate and fu-

<sup>1</sup> See Babbitt, "Literature and the American College."

tile as the most ridiculous ones of the medieval schoolmen. In the field of English scholarship, for instance, a great deal of effort has been put forth to determine the exact route of the Canterbury Pilgrimage, and where the knight began and ended his tale, where the Chanoun's yemanne joined the cavalcade, and similar points, as if it were an actual historical occurrence. Such an attempt as this is just as ridiculous as it would be to try to determine whether it was the right or the left slipper that Cinderella lost, if the story leaves us in doubt on that point; for the Canterbury Pilgrimage, although it may well have had one or several prototypes, never took place in anything like the form we know it anywhere else than in Geoffrey Chaucer's brain. This is the sort of task that lies within the compass of uninspired industry, but it has nothing else to recommend it; and when students are encouraged to devote themselves to such tasks, under the name of constructive scholarship, and questions so artificial and so remote from significant facts and fixed principles are thus associated so extensively with literature, it is no wonder that it suffers in public esteem, and that it has come to be considered by many as profitless speculation.

Something, though, that is worse for literature than its association with philology and pedantry is its confusion with dilettantism. There are no rewards offered to-day for the production of literature of a high order, there has been no intellectual or moral stimulus to its production, and there is consequently no power to discern it in present-day civilization if it were produced; so that the best strength, if not the best intellect, of to-day is directed towards the solution of more material problems. The effect of this is to leave literary production, to an unprecedented extent almost, in the hand of the intellectually petty and the spiritually contemptible. Men who in periods of greater literary discrimination would not have achieved even the negative distinction of being ridiculed in satires such as those of Pope or Dryden, through lack of competition, get themselves considered authors, and the public is led to believe that, if they are con-

demned, literature with all the value and honor accorded to it by tradition must be condemned too. Some men of this type have entered college teaching and have thus been enabled to identify themselves with learning as well as with literature and to lessen the respect and sympathy of the student as well as that of the general public for the subject. It is to their influence that the student owes his impression that literature is a matter of form rather than substance, and that in it what is said is unimportant provided it be expressed in an elegant or striking manner. This leads to an esteem for mere felicity far beyond its worth and to a serious corruption of taste. What is known as "style" is certainly an important factor in determining literary values, but style is not a mere matter of the externals of expression, any more than being a gentleman is only a question of conventionalities of dress and deportment because it seems so to the petty mind.

Where this type of intellect does not identify excellence with externals or superficialities it is even more mischievous, for it inculcates a dislike for matter that is substantial and nutritive and a strong taste for what is stimulant or narcotic. Shakespeare and other writers that require depth of intellect and breadth of sympathy for their appreciation are abandoned, for the most part, to the philologists and pedants, or their greatness is explained as being due to skill in literary technique or to some secondary or inferior quality. That knowledge or wisdom is essential to good literature is entirely overlooked and very often the opposite is strongly implied. Understanding of life and its correct delineation is not what is presented as the aim of literature, but it is pictured as depending, in poetry, on a sort of mildly epileptic or neurotic excitement imparted by the writer to his verse so that the reader is infected by it; and in prose, on novelty and ingenuity. Classic literature is regarded as consisting of what persons of more solid attainments would call "minor verse"—verse dealing with sentiment rather than passion—and fiction; for in this school all prose that is literature is fiction, because facts are

too commonplace and uninteresting, as well as too difficult, for the elegant mind. The value of history, biography, especially of scientific exposition, while not denied openly, is tacitly belittled as a means of forming the intellect and imparting culture, even to scientific students. The effect of this on education has been very bad, for while the philologists and pedants have only helped to make literature ridiculous among undergraduates, this has done a great deal to bring it into contempt among them; for it is not lack of intelligence or refinement that makes the normal student dislike literature, so much as it is an instinctive realization on his part that, as presented by his teachers, it is nothing but effeminacy and snobbery. The student, on the other hand, who has pretensions to elegance and regards literature as something to be cultivated is unrestrained by any standards of sufficient dignity, and instead of being taught not to mistake license for liberty and appetite for aspiration, he is encouraged to do so, and it is said that in some of the larger colleges, where the fashionable element is most numerous, Oscar Wilde, whose appeal is only to the shallow or the corrupt, is the favorite author and the commonest model.

Materialistic preconceptions, therefore, have taken from the intellect of to-day both interest in literature and ability to understand its most characteristic qualities, and have allowed its production and interpretation to fall into the hands of persons who have misrepresented it, so that the misunderstanding of its nature by the public is not to be wondered at. The same preconceptions have identified the typical scientist with the inventor of an automatic annunciator or cash register, rather than with the discoverer of cosmic principles or far-reaching truth, and so have spread an impression that science is of the earth, earthy, while literature is vague, unsubstantial and sentimental. This being the situation, the question arises whether or not anything can be done to remedy it.

The bringing about of the production of enduring literature and the imparting to the public of an ability to detect and appreciate it

is too great a task to attempt, and circumstances must be left to effect it. There is every reason, however, to expect a betterment in both these respects soon; for the maturing of American civilization has supplemented the former flamboyant and frothy public opinion with an undercurrent of serious and candid judgment, and has made the national conscience in this country more acute and more earnestly intent on discerning its own weaknesses and reforming them than it is anywhere else in the world. This would of itself presage the production of more serious and more important literature and the development of greater powers of discrimination, even if the deficiency in both these respects in the past generation did not ensure an improvement in the next. But this is only a prospect and applies only to literature; it still remains to be seen what can be done for the present, and what improvement can be wrought in the popular attitude towards science.

In this latter problem it would seem that most can be done by the scientific men themselves. It ought to be possible for them to visualize their own objects, and to define their own standards more clearly than they do. It often seems as if they were very punctilious about an etiquette that forbids them to profess any opinions on matters outside their own special field of knowledge. This appears as if it should be a good thing, and it would be beneficial if it were due to modesty alone or to a disinclination to speak without knowledge; but, unfortunately, it is due to a lack of interest more than to anything else; and its effect is, first, to present few exhibitions of the aims of science apart from those of the special investigator, which are necessarily restricted and preponderatingly material; and, second, to allow a great deal of pseudo-science to go unexposed to a sufficient extent to destroy its influence on the public mind. Instead of their present indifference, and sometimes suspicion and disdain, for all other knowledge except their own special branch, if scientific men would cultivate wider sympathies and endeavor to interest themselves in the progress of science in its entirety and not identify it

with their own specialty alone, it is likely that the public would acquire a more intelligent idea of what its essentials are, and a greater power to discriminate between those who represent and those who misrepresent it. With a united and sensitive scientific opinion, variations in either direction from its golden mean would be much more quickly detected and much less successful in obtaining public credence than they now are. The building of vast and elaborate structures of theory on microscopic foundations of fact would not escape scrutiny to the extent that it does now, and the pedagogist who promulgates his principles on the evidence of random, silly, or morbid statements gleaned from questionnaires, as well as the anthropologist who determines ethnic relationships on a few insignificant facts and his own racial or intellectual prejudices, or classifies the human race on the evidence of five or six skulls, and all similar empirics would have to find another livery than that of science to wear. Likewise, if a man should attempt to make history, philosophy, literature and kindred subjects exact sciences by some such simple expedient as measuring the amount of commentary on men and events to determine their importance, his plan would very soon be dismissed permanently as merely an effort to reduce an intensely complicated problem to a simple matter of sense perception—a thing that men will always try to do, just as they have sought the fountain of youth, the philosopher's stone, and more lately perpetual motion, but in doing so have shown themselves not scientific, but the reverse of it.

Another thing that might be done is to define more clearly the relation between theoretical and applied science. The general opinion now seems to tend altogether too much in the direction of believing that a choice must be made between them, and that to believe in the value of the one implies condemning the other. Of course there can be no intelligent condemnation of applied science, for theoretical science has no value apart from its application at some time or other; but what can be condemned is the prevalent idea that applied science is everything, and that if research or

investigation can not be shown to have direct bearing on some problem of practical life it is valueless. This is a notion that scientific men owe it to themselves to combat and to overthrow. Let applied science have its honored place, let it be admitted that James Watt, even that the inventor of a useful mouse-trap, is a scientist; but let it also be recognized that Newton and men of his type deserve the title likewise, and that applied science owes something to their efforts and should be willing, not only to acknowledge the debt, but also to perceive the grounds on which it is due. Perhaps if this were done there would be less of what Professor Walker<sup>2</sup> has called "the spirit of alchemy" among present-day scientists, and there might also be a more intelligent idea of the nature of science abroad in the land—a realization that it means first of all a love of truth to which not only subjective hopes of immortality, and beloved traditions and beliefs, but even the love of profit itself must be subordinate.

Extending their sympathies and interests beyond the bounds of their own sphere of knowledge might also enable scientific men to aid somewhat in bringing about a better understanding of the real significance of literature. At present they, for the most part, regard the subject as a necessary evil to be suppressed as much as public opinion will permit. Others believe that it has some value, and although they can not make themselves see just what it is, they are nevertheless willing to take it on trust. Still others express great admiration for the subject, but their utterances concerning it often suggest that their understanding of it is not very profound. A saving remnant, however, show an intelligent appreciation and understanding of literature, and not less by what they reprehend than by what they praise, prove themselves its friends. It is this latter class that more catholic sympathies would undoubtedly increase; and with scientific opinion having the weight it has to-day, its influence on the public mind ought to be very great. On the academic world its influence should be even

<sup>2</sup>"Alchemy in Modern Industry," *SCIENCE*, N. S., Vol. XXXIII., p. 913.

greater, and ought to be sufficient to bring about a distinct betterment in the teaching of literature. It would be far better not to teach the subject at all than to do so in an ineffective or misleading manner or to treat it as a nuisance tolerated only to avoid the reproach of neglecting the cultural, without any faith either in the necessity for culture or in the study of literature being a means of acquiring it. An intelligent and interested opinion would do away with this situation, and would be sufficient to ensure literature being taught in a sincere and competent manner. Two things would undoubtedly be insisted on that are matters of indifference now: sufficient knowledge and sufficient persuasive power in the teacher. Literature is a subject that involves a knowledge of history and of languages, and no man has a right to teach it unless he can show a certain amount of learning in both fields; and to guarantee that he is not a pedant, he should be able to interest students in his subject and make it appeal to them. There is a very strong feeling now that instruction must not be allowed to degenerate into mere entertainment, and while there is some justification for this apprehension, it should not lead to the conclusion that any teaching that is dull or repellant is successful. Where real knowledge of wide significance is being conveyed there is no danger of the learner finding no resistance to overcome, but, on the other hand, there is no danger of its exposition becoming an insufferable bore or an object of ridicule among earnest and industrious students. There can be no doubt that if scientific opinion were more active and more general in its scope, not science and literature alone, but many other things as well, would become clearer in the public mind as well as more effectively treated educationally.

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*THE NUMBER OF STUDENTS TO A  
TEACHER IN STATE COLLEGES  
AND UNIVERSITIES*

THE following tabulations are based upon figures found in "Statistics of State Univer-

sities and other Institutions of Higher Education partially supported by the State"<sup>1</sup> and show the number of students to a teacher in eighty-one state-supported schools.

The average number of students to a teacher is 10.5. It is interesting to note that while no doubt, in general, the cost of the unit hour of instruction is smaller in schools having more students to a teacher, the best schools in the list tend to have less than 10.5, the average number of students to a teacher. Thus for Cornell University the universities of Wisconsin, Illinois, Michigan, California and the Massachusetts Institute of Technology the number of students to a teacher is only 9.5+.

Name of Institution	No. of Students to a Teacher
Alabama Polytechnic Institute .....	11.6
University of Alabama .....	11.3
University of Arizona .....	4.7
University of Arkansas .....	9 +
University of California .....	12.9 +
University of Colorado .....	7.8 +
State Agricultural College (Colo.) .....	3 +
Colorado School of Mines .....	18.7
Connecticut Agricultural College .....	8 +
Delaware College .....	6 +
University of Florida .....	7 +
Florida State College for Women .....	10.9 +
University of Georgia .....	11 +
Georgia School of Technology .....	12.3 +
North Georgia Agricultural College .....	14.2 +
University of Idaho .....	9.8 +
University of Illinois .....	8.4 +
Indiana University .....	13 +
Purdue University (Ind.) .....	11.2 +
Iowa State College of Agriculture and Mechanic Arts .....	12.4 +
State University of Iowa .....	13 +
University of Kansas .....	11.2 +
Kansas State Agricultural College .....	12.1 +
State University (Ky.) .....	9.7
Louisiana State University and Agricul- tural and Mechanical College .....	10.4 +
University of Maine .....	9.2 +
Maryland Agricultural College .....	7.7 +
Massachusetts Agricultural College .....	8.5 +
Massachusetts Institute of Technology ...	6.6 +
University of Michigan .....	15

<sup>1</sup> For the year ended June 30, 1910. Washington, Government Printing Office, 1911.